Graded Coatings

for high-performance parts

NASA's Marshall Space Flight Center(MSFC) has developed and patented a novel method of forming coated parts using functional, gradient-coating techniques. The method is being used by NASA to form liners for rocket engine combustion chambers. It extends the life of the liners by eliminating blistering and separation of the coating that can occur under high heat loads.

Benefits

This method is used to extend the life of high-performance parts. Depending on the material selection, the method enables longer part life by:

- Lowering operating temperatures
- Enhancing resistance to thermal corrosion, oxidation, and abrasion
- Increasing strength, lubricity, bonding, and/or ductility.

The method also offers some benefits over traditional high-end coating technology, including:

- **Reduced production time—**Using this method, NASA can shorten the production time for its combustion chambers from 2 years to 10 months.
- **Relative low costs—**The estimated cost to produce one 10"-long, 5"-diameter tube using this method is $250; in production volumes, the cost is estimated to be $25.

Applications

The technology can be used to form and coat parts for the following applications:

Aerospace

- Rocket engine combustion chambers and nozzles
- Turbine vanes and combustors for aircraft

Automotive

- **Diesel and high-performance engines—**pistons, cylinder heads, valves, exhaust manifold
- **Ceramic engines—**engine block, piston, piston head, turbochargers
- **Fuel cells—**conversion stage parts

Commercial engines

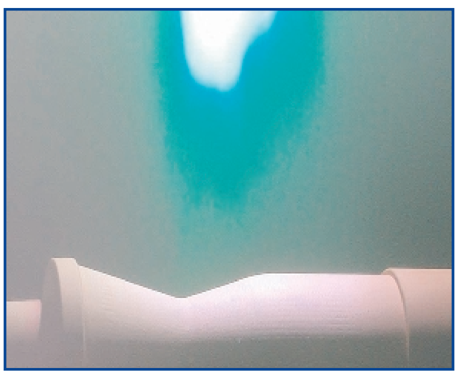
- Industrial gas turbines
- Incinerators
- Furnaces
- Heat exchangers

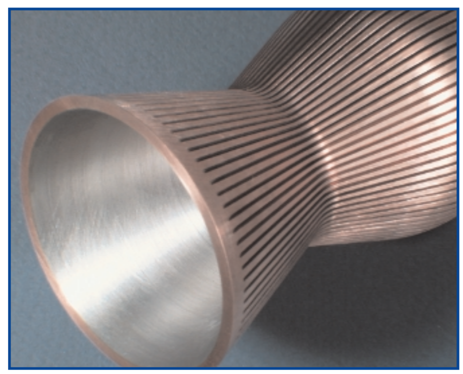
National
Aeronautics
and Space
Administration

The Technology

MSFC has developed a novel method of manufacturing and coating high-performance engine components to withstand violent combustion environments in which intense temperature and pressure could damage parts. The method relies on vacuum plasma spray (VPS) and other thermal spray techniques to produce parts for applications in which several materials are combined to meet demanding fabrication and performance requirements.

For example, NASA uses the technique to combine two materials that together provide the desired properties for a rocket engine combustion chamber—good thermal conductance and resistance to thermal corrosion and oxidation. In this application, a protective nickel alloy coating protects a copper alloy combustion chamber lining. Using the new method (as shown in the figure below left), the part is formed by a transitional layering process. Starting with a base layer of 100% copper alloy, the nickel alloy is gradually added to the material mix as the layers accumulate. The composition of the layers gradually transitions from copper to nickel until the final layer is made of 100% nickel alloy. As shown in the figure below on the right, the inside of the liner has the silvery appearance of the nickel alloy, while the bulk is a coppery material. As a result of using the new method, the coating has been graded into the part and there is no bond line. By using this method, NASA has been able to avoid previous problems with the coating blistering and separating under intense heat loads.





The method is currently being used at NASA to make small and large developmental engine parts. To date NASA has formed coatings from Ni-, Cu-, ferrous-, and ceramic-based material in the following combinations: Ni/Cu; Ni/ceramic; and ferrous/ceramic. Parts made using the method have been exposed to temperatures of 3,500–5,000 °F and to pressures ranging from 500–3,000 psi. Depending on the material selection, the resulting wall temperatures range from 1,000–1,700 °F. The method is also used with ceramic or other metal alloys to serve a variety of applications requiring high-performance parts.

Partnership Opportunities

This technology is part of NASA's technology transfer program, which seeks to stimulate commercial use of NASA-developed technology. MSFC has been awarded one patent for the technology (US6314720) and a second patent is pending. NASA invites companies to explore opportunities to license and develop the coating for commercial applications.

For More Information

If your company is interested in obtaining more information about this technology or about NASA's technology transfer program, please contact:

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